

Status of the Antares neutrino telescope

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Abstract The Antares detector has been in operation for more than one year. Data taking with the first detector string has continued uninterrupted for 16 months starting from March 2006. A further four detector strings were connected to the read out in January 2007. With this almost half-size detector the first neutrinos have been observed.

1. Introduction

On Valentines day 2006 the first full detector line of the Antares experiment was deployed on the Mediterranean seabed 40 km southeast of Toulon at a depth of 2500 m. Within 48 hours of connection, regular data taking began and the line has been in continuous operation ever since. During the year a further four detector lines were deployed. In January 2007 these lines were connected to the communications cable using a remotely operated submarine.



Figure 1: The Antares storey; the building block of the detector.

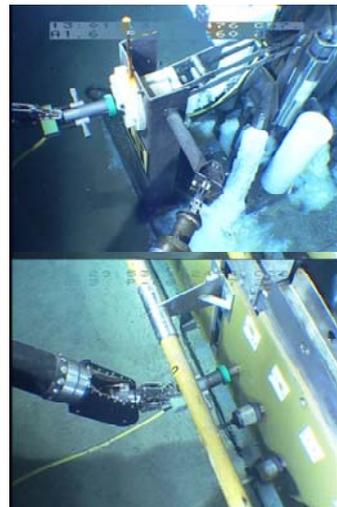


Figure 2: Submarine connection of the first detector line

The Antares detector line has 30 storeys with an inter-storey distance of 14.5 m, the first of which is located 100 m above the seabed. Each storey contains three optical modules and a titanium cylinder housing electronics. The optical modules are large glass spheres in which 10 inch photomultiplier

tubes are housed. The photomultipliers are oriented downward with their axis at 45° to the vertical. A storey is shown in figure 1. Each storey also contains a compass, a tilt meter and a hydrophone. The cable which provides electrical and fibre-optic connections also gives mechanical support to the storeys. The line is anchored on the seabed by means of a deadweight and held vertical by a buoy. Data is transported to shore via an optical network and on shore these data are filtered on a farm of PCs.

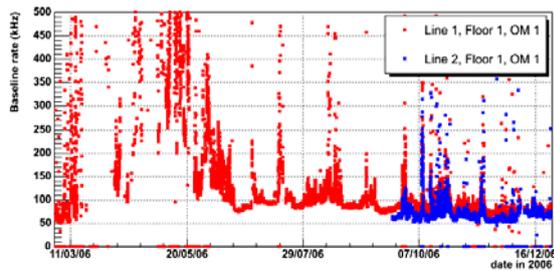


Figure 3: Singles rates observed in 2006.

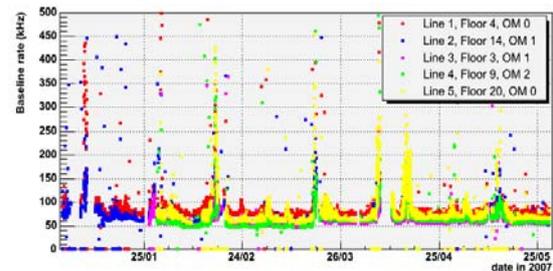


Figure 4: Singles rates observed in 2007.

2. First years operation

The first several months of operation saw a large optical background from bioluminescence. Singles rates up to 250 kHz were regularly observed accompanied by short bursts of even higher rates. The expected rate due to the Cherenkov light produced by electrons from the β -decay of ^{40}K that occurs naturally in seawater is 50 kHz. The high rates subsided towards the end of the summer and have subsequently not reappeared. Figure 3 and Figure 4 show the singles rates for the full 16 month period for which the first detector line has been active. During the high first months the data filter was optimized to allow efficient selection of interesting events even in the presence of high bioluminescent backgrounds. At present background rates of 250 kHz can be handled without problems. Since August of 2006 such rates have occurred less than 5% of the time.

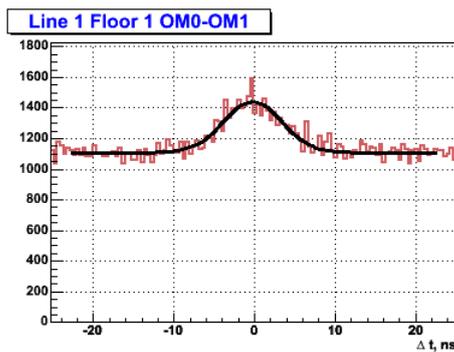


Figure 5: Coincidence rate of two optical modules on a single storey

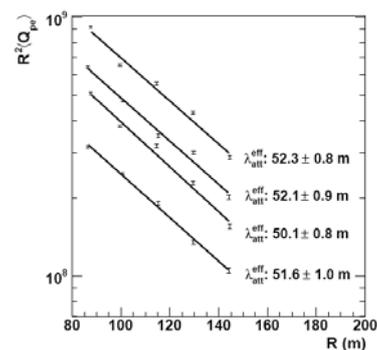


Figure 6: Intensity measured as a function of distance from the light diode array. The rate is corrected for the opening angle of the module.

3. Calibration

The position of the optical modules can be determined in two ways. First a sonar system with fixed transmitters on the seabed and receivers on each storey of the line allows the position to be measured via triangulation. The second method relies on determining the shape of the detector line from measurement of the tilt at each storey. The two methods agree well in reproducing the shape.

The noise created by the ^{40}K decay can be used to determine some key detector parameters. Figure 5 shows the spectrum of the time difference between two phototubes in a single storey. Obviously most of the time when two hits are recorded there is no correlation however in a small fraction of the time each phototube observes a photon from the same potassium decay. In that case there is a correlation. The time difference should be zero and the width is then a measure for the timing resolution. The figure is consistent with a timing resolution of the order of 1 ns.

The light diode arrays placed at every fifth storey were used to determine the absorption length of the water. Figure 6 shows an example of such a measurement. The absorption length of the water is measured to be 44 ± 5 m.

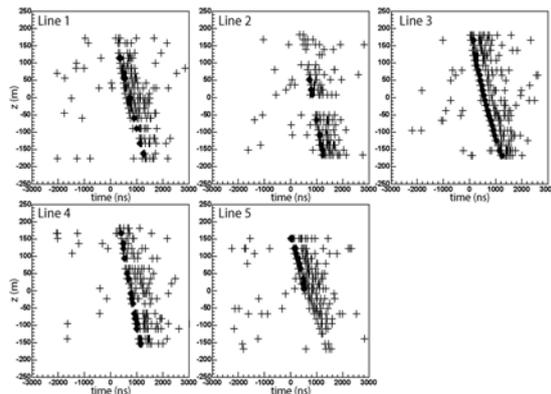


Figure 7: Tracks of downward going muons observed in Antares. Many parallel tracks are seen.

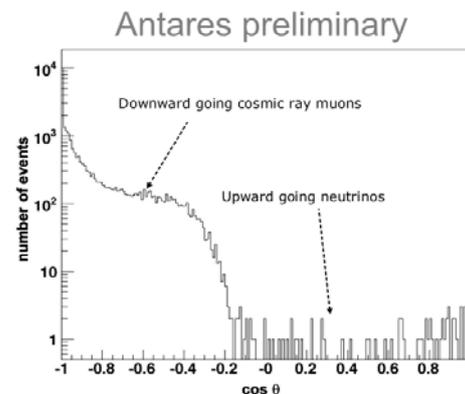


Figure 8: Angular distribution of reconstructed tracks for about 50 days of live time. Upward going atmospheric neutrinos are observed

4. Neutrinos

Although some tracking investigations were done, while only one line was connected, when five lines were connected the search for neutrinos began in earnest. In general the vast majority of the events recorded by Antares are due to downward going muons, which occur as isolated tracks or as bundles of many parallel tracks passing through the detector simultaneously. Figure 7 shows one such event. The figure shows the time versus height of the detected photons for the five lines separately. The time increases as the height decreases and the velocity (slope) is consistent with the speed of light. However many parallel tracks are observed. The reconstruction of the tracks is performed in several stages using linear pre-fits, M-estimator fits and finally full maximum-likelihood fits. The probability density functions were determined from Monte-Carlo simulation, as was the value of the statistic at which to cut to provide tracks of sufficient quality. Figure 8 shows the angular distribution for 50 days live time of the experiment. A total of 50 neutrinos are observed in the upward going hemisphere. The background from downward going muons is small. The measured rate is somewhat smaller than expected, but the cleaning cut applied is very strong and the final alignment of the detector was not used for this analysis.

5. Conclusions

Antares has been live for more than one year and almost half the full detector has been operational for about four months now. Alignment and understanding of the detector is proceeding well. Bioluminescence counting rates were very high at the beginning but have subsided and are now at very manageable levels. The first upward going neutrinos have been observed.